PROGRAM OF SPECIALISTS' TRAINING IN THE FIELD OF ROBOTICS

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Abstract: The paper is devoted development of the study programme "Robotics" in Transport and Telecommunication Institute (TTI). The article analyzes the growth of industrial robotics and increases the use of service robots. Development of the study programme "Robotics" was carried out taking into account the requirements for knowledge and competence of specialist in the field of modern robotics. The professional Bachelor study programme "Robotics" is compared with similar programs of some European universities.

Key words: robots, training, study programme, industrial robot.

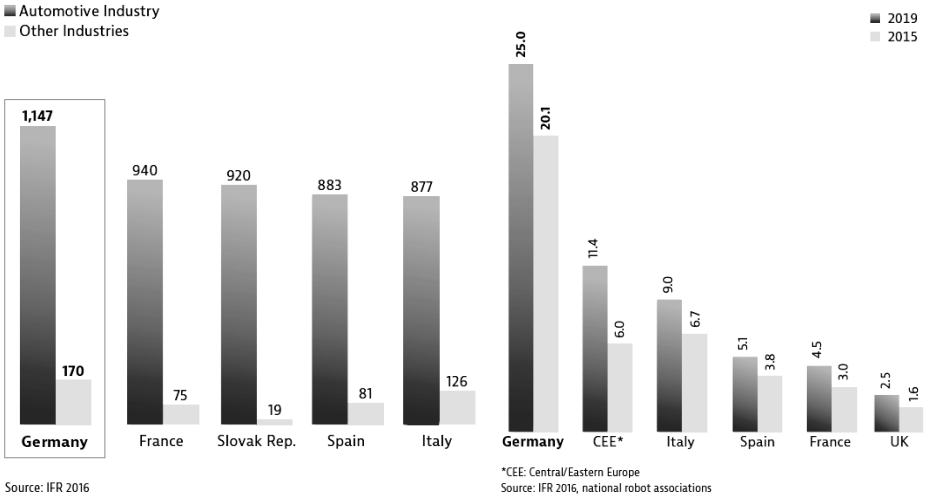
1. INTRODUCTION

Robots swiftly entered our life in the last decade and this trend is increasing. Robots are widely used in such areas of human activity as manufacturing, energy, transport, healthcare, security and defence, aerospace, emergency services, agriculture, even the entertainment and creative industries. Human activities robotization reduces the number of employees who perform heavy or monotonous work, but at the same time there is a growing demand for qualified specialists in the field of robotics. Therefore, training programs aimed at training these specialists should ensure the training of competitive specialists who have the knowledge and competence to solve the practical problems of modern robotics and future robotics. This article is devoted to the development of the study program "Robotics" in Transport and Telecommunication Institute (TTI) taking into account the trends in robotics and requirements for the knowledge and competence of a specialist in the field of robotics.

2. PROFESSIONS IN THE FIELD OF ROBOTICS

Currently, industrial robots have the greatest application in comparison with the use of other types of robots. This is most evident in automotive manufacturing. For example, according to the industrial robots statistics from the International

Federation of Robotics (IFR), 1147 robots account for 10 thousand employees in the Germany automotive industry and in all other industries about 170 [1]. Germany has the highest density level in Europe and ranks fourth in global comparison. The same situation is typical for industrial production in other European countries (Figure 1.a).



a *b*

Fig. 1. Features of robotics in selected European countries: a - robot density; b - estimated yearly shipments of multipurpose industrial robots(number in thousand units)

The IFR forecasts that robot installations will have a compound annual growth rate of at least 13 percent during the period 2017 to 2019, and such growth can exceed 15% in selected European countries (Figure 1.b). The IFR is also estimated that more than 1.4 million new industrial robots will be installed in factories around the world between 2017 and 2019.

Industrial robots represent the core of automation in production technologies. However, service robots are also gaining increasing importance in the human activity. The increasing application level of service robots represents an important tool of the move towards connectivity within INDUSTRY 4.0. The set of practical tasks and operations that are performed by service robots is expanding. Trends in the service robot market: medical systems, mobile robots, service robots for personal and domestic use and etc. Figure 2 shows strong increase in most applications. The IFR forecasts that 333,000 service robots for professional use will be sold to non-manufacturing and to manufacturing sectors, and 42 million service robots for personal and domestic use (consumer robots) will be used in private life [2].

Density robots growth does not reduce the number of employees in the robotics and automation industry, but vice versa. Figure 3 shows increasing of employees in the robotics and automation industry in Germany. However, this growing demand concerns qualified professionals who are able to design, create, implement and maintain robotic devices and systems [1].

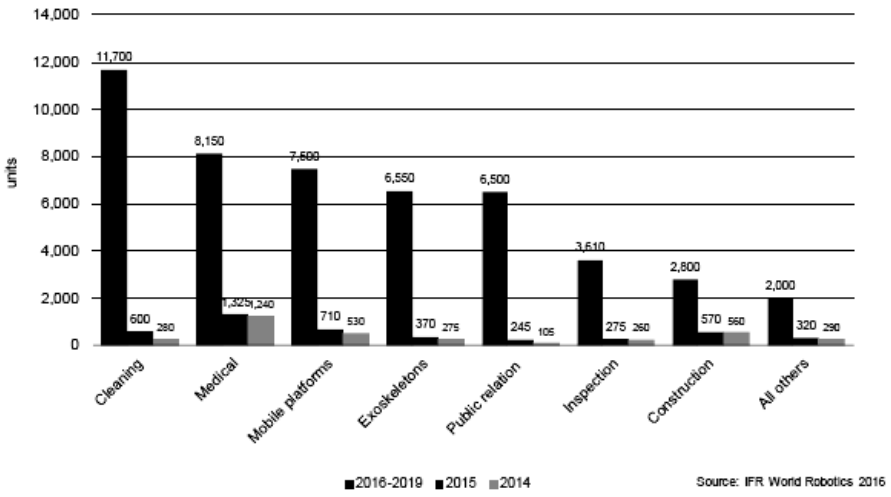


Fig. 2. Service robots for professional use. Units sales 2014 and 2015, and forecast 2016-2019

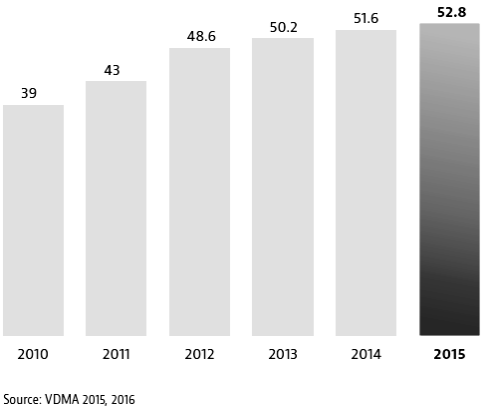


Fig. 3. Employees in the robotics and automation industry in Germany in thousand

Now designers of industrial robotics, specialists in programming and maintenance of industrial robots, as well as operators of multifunctional robotic complexes are in great demand for industrial robotics. This demand will be

observed in the future. IFR forecasts indicate that by 2020, significant demand will be in the profession associated with service robots, such as Home robot designer, social robot designer, medical robot designer, neurointerface designer for robot management, child robotics designer, compositing engineer and ergonomic designer.

3. REQUIREMENTS TO THE STUDY PROGRAMME IN THE FIELD OF ROBOTICS

The Robotics is a branch of science integrating many cutting-edge technologies of mechanics, electronics, computer science and automatic control. Mechanical construction is the base of any robot. However, modern robots are advanced automatic devices with embedded electronics and embedded software that determine the functionality and autonomy of robots, and allow the use of information technology to solve robotic tasks. Artificial Intelligence techniques are used to perform complex tasks and in difficult environments for robots [3]. Consequently, specialist in the field of robotics must:

- have a basic knowledge of four scientific areas of robotics;
- be able to carry out research and solve practical problems of robotics;
- have systems mindset;
- have a programmer's mindset;
- have competence in embedded electronics;
- have competence in control methods and systems;
- know the features of robot designs;
- be able to analyze and choose solutions.

Currently, the study programs Mechatronics and Robotics are used mainly to train specialists who can apply and maintain automatic control systems for industrial production, and the competences related to robotics are determined by the profile of the study programme [4,5]. Professional study programme "Electronics" and Bachelor study programme “Computer Science” in TTI contain several study courses developing competence in the field of robotics [6], but they are insufficient to solve the problems of practical robotics.

Taking into account the features of industrial robotics, trends in the specific expansion of service robots and the requirements for a specialist in the field of robotics, the following requirements were defined for the development of the study programme "Robotics":

- the study programme should be aimed at creating competencies for students in the field of industrial robotics and in the field of autonomous robotics;
- the study programme should ensure the development of practical skills in the use of industrial robots in robotic production and the creation of autonomous robots;

- the study programme should take into account the trends of robotics: increasing the autonomy and intelligence of robots;
- the study programme should take into account the requirements of employers to a specialist in the field of robotics.

4. THE MAIN CHARACTERISTICS OF THE PROFESSIONAL BACHELOR STUDY PROGRAMME "ROBOTICS"

The aim of the developed professional Bachelor study programme "Robotics" is to provide professional Bachelor education in the field of electronics and automated systems in subfields of industrial robotics and autonomous robots.

Development of the study programme "Robotics" was carried out taking into account:

- the general requirements for specialists in the field of electronics and automated systems, which are set out in [6];
- the requirements to the study programme in the field of robotics that were defined in the previous section;
- the requirements for the structure of the second-level study programme of higher professional education in the Republic of Latvia [7].

Together with general educational (GE) courses the developed study program Robotics contains theoretical basic study courses and professional study courses of the following scientific and technical directions: electronics and electrical engineering, automatic control, information technology, programming and mechanics, which are the basis of robotics [8] All theoretical basic and professional study courses can be divided into three scientific branch: "Electronics and Electrical Engineering" (*EET*), "Information Technology and Computer Science" *(ITCS)* and "Mechanics and Engineering" (*ME*). The table 1 contains this distribution.

It can be seen that almost 80% of ECTS are study courses belonging to the scientific branches *EET* and *ITCS.* The study courses of these two scientific branches:

- provide basic training for students in the study programe "Robotics";
- form the knowledge and develop the competence of students in electronics, automation, information technology and computer science, which are necessary for solving practical problems of industrial robotics and controlling the actions of autonomous robots.

The courses in these fields provide students knowledge of the theory of automatic control, the programming of microcontrollers and industrial logic controllers, industrial and intelligent robots, autonomous robot embedded systems, autonomous robot actions planning, industrial robot control programming and artificial intelligence methods.

Table 1.

Scientific branch	***Study courses***	***ECTS***	***%***
ITCS	*1. Programming* *2. Programming robots. Course Work* *3. Digital Image Processing and Computer Vision* *4. Introduction to Intelligence Systems* *5. Control programs design for Industrial Robots* *6. Planning the Movement of Autonomous Robots* *7. Intelligent Robots* *8. Local Area and Wireless Networks* *9. Robot Control Methods* *10. Robotic Device Control. Course Work* *11. Computerized Control Systems for Robotic Manufacturing*	*60*	*34,5*
EET	*1. Electronic Devices in Robotics* *2. Signal Processing Fundamentals* *3. Theory of Automatic Control* *4. Metrology and the Fundamentals of Electrical Measurements* *5. Sensors of Robotic Devices* *6. Power Electronics Devices* *7. Design Digital Circuits for Robotics* *8. Microcontroller Programming* *9. Team Project* *10. Programmable Logic Controllers and Their Programming* *11. Robotization of Industrial Manufacturing* *12. Embedded Systems of Autonomous Robots* *13. Design of Autonomous Robots* *14. Electrical Circuits Theory Fundamentals* *15. Electrical Machines in Robotics*	*78*	*44,8*
ME	*1. Technical Mechanics* *2. Materials Engineering* *3. Robot Details and Mechanisms and Their Design* *4. Kinematics and Dynamics of Robots* *5. Industrial Robots* *6. Autonomous robots*	*36*	*20,7*

The *ME* branch study courses form the students' knowledge and competence about robot structures and their dynamics, which must be taken into account when creating and using robot control systems and software implementation of algorithms for controlling the actions of robots, both industrial and autonomous.

The Table 2 allows compare the contents of study programs that provide the specialist's training in the field of robotics in several European universities taking into account the general educational courses, taking into account the general educational courses, which are designated as the GE.

Table 2.

Study programme (University, Faculty)	***G***	***EET***	***ITCS***	***ME***
Robotics *(TTI)[8]*	*24*	*30*	*26*	*18*
Robotyka (Wrocław University of Science and Technology) [9]	*26*	*33*	*30*	*11*
Mechatronics and Robotics (University of Leeds) [4]	*8*	*38*	*22*	*32*
Mechatronics and Robotics (Vilniaus Gedimino Technikos Universitetas) [5]	*29*	*21*	*6*	*34*

The table 2 contains the distribution of credit points in % for general educational courses (GE) and three scientific branches, which are described in Table 1. It can be seen that similar curricula have different structures of the curriculum. The structure of the study programs is determined both by the specifics of the higher education of each country, and by the approach of the institution itself to the organization of the educational process.

It can be seen that the training courses in field-specific study course, in field of electronics, in field of computer science and automatic control dominate in content of the Robotics study program. The training courses of the mechanics direction dominate in the Mechatronics and Robotics study programs.

5. CONCLUSION

The structure of the professional bachelor study program Robotics ensures the acquisition of modern knowledge, developed skills and competences in the field of industrial robotics and autonomous robots, which allows the graduate of the program to occupy a winning position in the labor market of European countries.

The study program Robotics supports in general the following professional activity of the graduate:

- an engineer in the field of industrial automation, able to program and maintain in working order industrial robots and robotized complexes;
- an engineer-developer of autonomous robots for various applications: transport, manufacturing, agriculture, energy, etc.

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